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MANAGING ENGINEERING MANPOWER

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MANAGING ENGINEERING MANPOWER

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Preface

Why write a thesis on Managing Engineering Manpower while enrolled in a graduate program in financial management? There are three primary reasons. The first is obvious. Manpower costs money. The second and third reasons are, perhaps, more obscure.

The writer is a Navy Civil Engineer Corps officer. While all CEC officers devote their lives to service to the Navy, they work in the internal operations of the Navy through the Bureau of Yards and Docks. They direct the contribution the Bureau makes to the Navy.

There are a number of opinions about what this contribution is or should be--about what the real purpose of the Bureau is. The objectives of the Bureau and the Civil Engineer Corps have been stated with brevity and clarity by the chief of the Bureau in a recent booklet called simply, Precepts. The objectives are:

> 1. To direct the Civil Engineering effort in the Navy toward:
>
> (a) Attaining maximum effectiveness and economy throughout the Naval Shore Establishment by employment of the best engineering practices in the conduct of governmental business.
>
> (b) Supporting to the maximum possible extent the military requirements of the Chief of Naval Operations and the Commandant of the Marine Corps.
>
> 2. To extend Civil Engineer Corps and Bureau of Yards and Docks services into those areas where the job can be done most effectively by a military engineering organization.[1]

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[1]U. S. Department of the Navy, Bureau of Yards and Docks, Precepts, November, 1961, p. 1.

A study of this statement of objectives, stripping away the superlatives and the modifiers, reveals the basic ingredient, civil engineering effort. The business of the bureau and the corps then, it seems to the writer, is to provide the Navy the superior professional technical assistance in civil engineering it needs to do its mission. The second reason for writing on managing engineering manpower is now more apparent. This is the business in which the writer considers his parent organizations to be engaged.

The third reason for writing on this subject is more general. For years, on a periodic basis, the national spotlight has been turned on the shortage of engineers. The fact that the interest is periodic is significant. It points to the fact that no workable solution of the national problem has been found. The writer feels that a worthwhile contribution toward solution can be made by following through, from the general to the specific, the study of a particular facet of the larger problem; that by laying out a practical solution to a particular situation a way may be shown toward partial solution of the overall problem of an inadequate supply to meet a growing demand for engineering manpower.

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CHAPTER I

INTRODUCTION

The Shortage of Engineers and Scientists

On February 15, 1962, the Wall Street Journal carried an editorial, "The Engineers." The editorial writer looked back to his high school days in the 1930's and reminisced. He recalled his guidance counselor warning against pursuing an engineering career. "There was, he said, a super-abundance of engineers, and he urged us all to choose a career that offered a more promising future."[1]

In the thirty plus years since that time the relationship between supply and demand for engineers has fluctuated up and down. During World War II there was real concern that the supply of engineers would be inadequate to meet the military challenge.[2] When the war ended, the concern was that the supply would not meet the expanding needs of the nation.[3] But in January of 1950, the Engineers Joint Council expressed the fear that the men due to be graduated from engineering colleges in June could not be used

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[1]The Wall Street Journal, February 15, 1962.

[2]Henry H. Armsby, Engineering and Scientific Manpower, U. S. Dept. of Health, Education, and Welfare Circular No. 483 (Washington: U. S. Government Printing Office, 1956).

[3]Ibid.

effectively by industry.[4] It took the partial mobilization for Korea to force recognition of the real limitation on the engineering resources of the nation.

There were some whose concern for the problem did not fluctuate. In April of 1950, the journal of the Office of Education, Higher Education, stated that diminishing freshman classes in 1946 and the growing demand for engineers should serve to warn of an impending shortage in 1953.[5] These experts had reckoned without the Korean conflict. The shortage arrived full grown in 1950.

The factor which had prompted the Engineers Joint Council to fear that the June, 1950 engineering graduates would have difficulty finding jobs was the record high of 52,732 first professional or bachelors degrees granted that year. In sharp contrast to the 1950 record high was the graduating class of 1954.[6] That year less than 12 per cent of all professional or bachelors degrees granted were in engineering. The number was only 22,236.[7] In the face of this drop, the Bureau of Labor Statistics estimated 30,000 engineering graduates would be needed each year to restore losses and to keep pace with new needs.[8]

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[4] Ibid.

[5] "Engineers--Too Many or Too Few," Higher Education, April, 1950.

[6] U. S. Congress, Joint Committee on Atomic Energy, Engineering and Scientific Manpower in the United States, Western Europe and Soviet Russia, 84th Cong., 2nd Sess., 1956.

[7] Ibid.

[8] Ibid.

During this period there were those in the country who were becoming increasingly concerned over the fact that the U.S.S.R. was exerting tremendous national effort to provide well trained technical leadership. In 1954, the U.S.S.R. graduated 53,000 men and women with bachelors or equivalent degrees in engineering.[9] These engineers have added to the force causing the rapid expansion in the economy of the Soviets, our relentless competitors in the cold war.

In 1956, the Joint Committee on Atomic Energy of the United States Congress held extensive hearings on the subject of engineering and scientific manpower in the United States, Western Europe, and Soviet Russia. One of the items in that report was a forecast of graduations in the United States in the immediate future. The forecast was:

a.	1958-1959	37,000
b.	1959-1960	38,000
c.	1960-1961	39,000
d.	1961-1962	39,000[10]

The report also contained an estimate that the engineering population of the United States in 1956 was slightly over 500,000 and that the engineering population of the U.S.S.R. in the same year was larger than our own--nearly 600,000.

By 1957, the percentage of freshmen who enrolled in engineering in U. S. colleges and universities was down to 10.8 per cent.[11] The trend has been down ever since. Even the evidence of Russian ability in technical

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[9] Ibid.

[10] Ibid.

[11] "Demand for Engineers to Double," Engineering News-Record, December 7, 1961, p. 28.

areas shown by the launching of Sputnik I on October 4, 1957, has caused no reversal of this trend. It is true that scientific and engineering programs for defense in the United States have been stimulated by aggressive pressures from the U.S.S.R., but no major effort has been made to increase the number of U. S. engineering candidates going into universities and colleges.

In 1960, the Bureau of Labor Statistics estimated the engineering population in the United States to be 648,500.[12] In that same year only 7.3 per cent of freshman college enrollment was in engineering.[13] This was not only a drop in percentage, but also in absolute numbers. In 1960, engineering graduates numbered 37,800.[14] This was just under the estimate made in the report of the Joint Committee on Atomic Energy in 1956.[15]

Time is not solving this problem. After a meeting held in early 1962, at the call of Dr. Jerome Wiesner, President Kennedy's science advisor, a space administration official commented, "as we look ahead, our most critical need seems to be for more engineer-scientists, for engineering-Ph.D.s."[16]

A look into the future by the Bureau of Labor Statistics shows a demand in 1970 for nearly 1,270,000 engineers.[17] This is double the

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[12] Ibid.

[13] Ibid.

[14] Ibid.

[15] U. S. Congress, loc. cit.

[16] Dr. Warren Weaver, "Educating Engineers--Profession Loses Youngsters to 'Glamour' Sciences," The National Observer, March 4, 1962.

[17] Engineering News-Record, loc. cit.

population of 1960. In order to meet that figure there would have to be a net gain, not counting deaths and switches to other professions, of 52,000 engineering graduates per year. This means graduating about 72,000 engineers each year.[18] The Wall Street Journal editorial quoted in the first paragraph of this chapter ended this way:

> For when the Government says that the nation urgently will need 72,000 engineering graduates every year for the next decade, we can't help recalling that guidance counselor. And how the planners' prophecies often don't turn out as neatly as they should.[19]

The difficulty is that even if the estimate is over the actual need by 00 per cent, we are still not meeting the demand.

In summary then, during the period 1900 to 1950 the engineering population grew twice as fast as the population in general. There have been times when there were more engineers than were needed. But in recent years there has been an increasing demand for engineers and scientists. Projections of future demands, even discounting large errors in forecasting, are greater than the supply will be. It is apparent that the efforts that have been made to increase the supply of engineering graduates to meet the greater demand have been unsuccessful. There is no indication that a massive program to offset the deficiency is in the offing.

Engineering Manpower

We have been discussing the critical problem of the coming shortage of engineering manpower. In order properly to set the stage for what follows

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[18] The Wall Street Journal, loc. cit.

[19] Ibid.

the term "engineering manpower" should be clarified. The reader will undoubtedly have a general idea of the meaning of the term, but in order better to comprehend what follows a more specific understanding is required.

First, it must be made clear that the engineer is neither a manager nor an ordinary worker. He is an individual professional contributor,[20] a professional employee. Nor is the engineer a scientist.

> A true scientist spends his energies working in the scientific method; as a matter of fact he becomes part of it. The scientist makes controlled (well directed) observations, forms proper hypotheses, performs experiments to test the hypotheses against several references, forms theories, extends the theories to predictions to make the theories useful, and finally, establishes controls over the use of his work.[21]

An engineer, on the other hand, is simply occupied with getting a job done. Engineers use, in particular cases, what scientists have shown to be true for generalities. Engineers are people technically trained in the use of mathematics and basic scientific principles, and their reason for being seems to be that their knowledge and skills will be productive of a better life at less cost.[22]

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[20]Peter F. Drucker, The Practice of Management (New York: Harper & Brothers, 1954), p. 331.

[21]Edward Harris, "An Engineer is not a Scientist...and Vice Versa," Consulting Engineer (July, 1961), p. 68.

[22]Ibid.

The Need to Manage Engineering Manpower

Having established the fact of the existence of a shortage of engineering manpower and having defined the term, the next step is to suggest ways this shortage might be relieved. The first, to increase the number of people pursuing an engineering education, has already been touched upon. It is obvious from the statistics presented above that a major effort is needed to increase engineering enrollment in colleges and universities. One finds the emphasis in the literature on the subject of the shortage of engineering manpower is on this method of solving the problem. There is no question but what this is the only method by which the problem can be solved in the long run.

However, in the short run a temporary solution can be provided by using more effectively the existing supply of trained personnel. A study made in 1957, by the Harvard Graduate School of Business Administration[23] indicated that much of the so-called shortage of engineering staff was at that time the result of industry's misuse of the existing manpower pool. In 1956, the Engineers Joint Council at the second general assembly suggested that even in the long run the national scarcity of talent dictates that heavy reliance be placed on effective utilization of engineers rather than solely upon attempting to increase their numbers. In an article in the August, 1961, Consulting Engineer, John Girand indicates that even were there not an engineer shortage, there would still be a need for effective

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[23]George A. von Peterffy, "Getting More Mileage from Your Engineering Staff," The Management Review, (August, 1958).

management of engineering manpower. For as he points out, "a consulting engineer's office can be defined as a monster that devours large quantities of cash each month."[24]

As we shall see, the steps that lead to more effective utilization of the existing supply of engineers also help increase the number of people entering the field. This is so because as engineers are better utilized, the profession becomes more attractive.

This introduction has so far focused attention on the fact that a serious problem exists in the shortage of engineering manpower. From this point on the emphasis will be placed on improving engineering manpower utilization. Some ideas and practices designed to improve engineering manpower utilization which are in the literature will be reviewed. Then, a program will be outlined for use in the engineering organizations of the Bureau of Yards and Docks.

Engineering and Design

Since the last part of the paper will deal with the Bureau of Yards and Docks, its engineering functions (at least those with which we will be dealing) should be described. While many of the management techniques and practices discussed herein are applicable to the general field of engineering practice, this paper is slanted toward the kind of engineering done by the bureau and its field organizations.

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[24]John Girand, "Engineering Productivity...What's Wrong With Money As a Measure?," Consulting Engineer, (August, 1961), p. 99.

The objective of the departmental level (the Washington office) of the Bureau of Yards and Docks in the field of engineering and design is to develop the architectural and engineering policies, criteria, and practices for the economical construction and design of shore facilities which will best satisfy the functional requirement.[25] A brief of the Engineering and Design Program is included in Precepts.

> The Engineering and Design Program includes the development and promulgation of design materials for standard drawings of repetitive type structures; definitive designs for the most efficient and economical space arrangement to meet functional requirements; complex and specialized design guidance; preliminary engineering and project design reviews; engineering consultant services and investigations; nuclear engineering; fire protection engineering; technical specifications and cost data information; and associated technical support services.[26]

The Bureau and its engineering field organization, the Directors' offices and the District Public Works Offices, accomplish all engineering investigations, feasibility studies, planning studies and designs for the Naval Shore Facilities Construction Program, and for other government agencies as requested. A portion of this work is done "in house," but the largest amount of it has been done through the use of architect-engineer firms. It is the policy of the Bureau of Yards and Docks in this connection, that

> . . . a sufficient number of design projects of broad scope and complexity will be retained "in house" to provide for continued staff development, capability, and high level performance within the organization of the Bureau of Yards and Docks or its field activities.[27]

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[25] Precepts, loc. cit., p. 30.

[26] Ibid.

[27] Ibid., p. 16.

CHAPTER II

METHODS OF MANAGING ENGINEERING MANPOWER

Managing Non-Engineers

In order to illustrate the present attitude of management toward managing engineers it is necessary to trace the development of management of conventional manpower. This approach is necessary, because management tends to treat all workers alike. This discussion of management of conventional manpower will provide a reasonable base from which to move to a discussion of managing engineers.

The history of systematic, thoughtful, scientific attempts to control manpower is quite short. Until recently the social structure of civilization was based on authoritarian autocratic leadership. The power to control was based on force, strength, and the will of strong men. It is important to realize and understand that the roots of authoritarian autocratic leadership are deep seated in the past. Throughout the greater part of the history of civilization, the satisfaction of physiological and security needs in a vicious and dangerous world was the paramount concern of most men.[1] Their every effort was bent towards getting for themselves

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[1]Speech by Dr. Gordon Lippitt, Head, Behavioral Sciences Department, The George Washington University, August 31, 1961.

and their families food, shelter and protection. In the lawless world of the past the only way these wants could be met was for men to band together under a strong leader. By surrendering their liberty and giving their loyalty, the serfs,and peasants struck a bargain for food, shelter and security.

The beginning of the change away from authoritarian autocratic leadership was the American Revolution. For the first time on a large scale the selection and rejection of the leadership was made on a free basis by those to be led. The purpose of structuring the leadership, the government, was to provide an environment in which those selecting the leadership could pursue their own goals in safety without fear. Even in this environment it took over one hundred years for the working man to establish himself, to organize his strength, and to exert his power to change the social environment. However, change them he did; and as a result of these changes, fear has been largely eliminated as a motivating force in the workplace.

It is significant to note that Peter Drucker attributes the elimination of this motivation to increased wealth produced by industrialization.[2] Scientific management techniques, techniques concerned mainly with the processes involved in production, were responsible for the giant steps made in industrialization. The effort was largely directed toward making the processes as simple and efficient as possible. The worker was, for the most part, looked upon as just another mechanical part of a

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[2]Drucker, op. cit., p. 264.

process. This approach was consistent with the authoritarian autocratic point of view. But man is not a machine. As his standard of living has improved, the working man has become dissatisfied with what he gets from his job. Food, shelter, security, and material goods are inadequate compensation. The worker wants to be recognized as a man and to exercise some of his rights. He has become better educated, less submissive. In the 1900's Frederick W. Taylor's scientific management techniques brought tremendous improvements and were accepted by the worker, albeit reluctantly. But the worker of 1900 is not the same as the worker of 1960. He is no longer willing to be considered a machine; he can no longer be motivated by fear.

Right now, this year, the storm rages over management doctrine. According to Douglas McGregor of Massachusetts Institute of Technology, management considers that the average person has an inherent dislike of work and will avoid it if he can. Managers feel most people must be controlled and directed to work hard enough to achieve company objectives. The average person is not thought very ambitious for responsibility. Managers feel workers really want to be guided. McGregor and his colleagues, the behaviorists, participationists, human relationists, and so on, reject these concepts.[3]

This group feels that work is as natural to men as play or rest and that men will work hard toward ends which satisfy their egos. These people think the average man to be ambitious and seeking of responsibility. But

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[3]"Storm Over Management Doctrines," Business Week, January 6, 1962, p. 72.

they feel traditional management control and direction frustrates all sorts of undeveloped capabilities.

There can be no question that management practices of today have sprung from the roots of authoritarian autocratic ideas. However, managers have a responsibility to produce and there is not adequate evidence to show that any alternatives to the current approach used by managers will actually work. In any event, classical management principles are still being used as guides by managers in this country.[4]

A Unique Mind

So much for the art of handling conventional workers. It is time to explore the uniqueness of the engineering mind. We have said previously that Drucker states there are three kinds of workers in enterprise; the manager, the ordinary worker, and the professional contributor. What is unique about the professional contributor which makes us think he has to be treated differently? (It is interesting to note that Drucker feels that the professional contributor must be treated differently whether management considers it "necessary" or not.)[5]

In trying to establish this uniqueness we embark on a cloud covered path. The only satisfactory way to examine a mind in this sense is to talk about the work engineers do and about some of the things they say they think and feel. We can begin to build a picture of what engineers are like. We must bear in mind, however, that any attempt to group people by type is

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[4] Ibid.

[5] Peter F. Drucker, "Management and the Professional Employee," Harvard Business Review (May-June, 1952), p. 84.

filled with peril. No one fits the stereotype.

A key to the door of knowledge of this subject is contained in the Taft-Hartley Law of 1947. It was necessary in that law clearly to define a professional employee, because many of the provisions of the law did not apply to these people. The law defines a professional employee as any employee engaged in work:

> a. Predominately intellectual and varied in character as opposed to routine mental, manual, mechanical, or physical work.
> b. Involving the consistent exercise of discretion and judgement in its performance.
> c. Of such character that the output produced or the result accomplished cannot be standardized in relation to a given period of time.
> d. Requiring knowledge of an advanced type in a field of science or learning customarily acquired by a long course of specialized intellectual instruction and study in an instruction of higher learning or a hospital as distinguished from a general academic education or from an apprenticeship or from training in the performance of routine mental, manual, or physical processes.[6]

This gives an idea of the kind of mind and personality being considered. A person must be intellectually and psychologically suited to do this kind of work.

It is important that we understand that it is the work these people do which sets them apart. The chief purpose of a technical organization, according to Charles Orth, III, is ". . . to bring to bear upon problems of critical importance the creative imagination of highly skilled technical specialists, so that the problems will be solved and the solutions

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[6]Engineers Joint Council, Raising Professional Standards and Improving Employment Conditions for Engineers (New York: Engineers Joint Council, 1956).

transmitted in useable form to other components in the company."[7]

And again, Edward Harris says, "the practice of engineering is an art, and as an art, its success depends considerably on the exercise of judgement."[8]

Another approach to obtaining an idea of what it is that sets the engineering mind apart is an examination of attitudes and grievances among engineers in industry. In January, 1955, Moore and Rench reported the results of an "Attitude Survey" of 587 professional employees in nineteen work groups. Morale was revealed to be low and attitude poor. The main reason cited was:

> Chronic dissatisfaction of professional employees emerges out of a fundamental conflict which exists between expectations and values of professional employees and the opportunity which they have to realise their ambitions in the industrial setting.[9]

They feel their rewards do not match their contributions. Management and professional employees are in conflict over the way problems should be solved. The professional wants to give a complete answer, while management wants a simple solution.

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[7]Charles D. Orth, III, "More Productivity from Engineers," Harvard Business Review (March-April, 1957).

[8]Harris, loc. cit.

[9]David G. Moore and Richard Rench, "The Professional Employee in Industry," Journal of Business (January, 1955).

> From a professional's standpoint, there is often the feeling that management does not know what it is doing. The analytical mind finds the integrative mind somewhat inconceivable, perhaps, even a little obnoxious. The ability to reach decisions on the basis of partial information and what might appear to be flimsy evidence is not held in high esteem by the professional. In fact, in professional circles, this borders on Charlatanism.[10]

In October of 1959, Business Week reported a study made by Opinion Research Corporation in which 622 scientists and engineers in six major corporations were surveyed.[11] Seventy-two per cent of the technical people felt management misused their talent. Eighty per cent said they were underpaid compared to other groups. Most felt management people got an unfair share of recognition in the company and in the community. Seventy-six per cent thought management tried to manipulate people for their own purposes and about the same percentage accused executives of over-simplifying problems. Those surveyed thought of their goals as the pursuit of knowledge for its own sake, and they wanted less pressure from management, freedom to select their own work, and a flexible work schedule.

Another insight into the engineering mind is provided by William B. Given, Jr. He points out the weakness of an engineer appointed as a manager. He confirms that engineers have trouble with intangibles, having been trained to rely on facts and measurable observations. He feels engineers underestimate the importance of attitudes, emotions, customers, traditions, and prejudices and that they fail to realize that guesses and hunches are

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[10] Ibid.

[11] "Engineers, Scientists in Industry Feel Their Talents Are Misused," Business Week, October 24, 1959.

necessary parts of the executive process. Because engineers need large amounts of information to make decisions, they are often too slow when placed in management positions and, as a final nail into the coffin, Mr. Given says that engineers neglect the development of people.[12]

These observations we have made give a general idea of what goes on in the engineering mind. We are talking about people, people who are interested in engineering. Engineering, while its end is to serve people, is mainly concerned with inanimate objects and static and dynamic forces. While many engineers will disagree, nevertheless, engineers tend toward being introverts rather than extroverts and are not, as a group, "people oriented." There are, of course, exceptions, but, by and large, engineers are more interested in their work than they are in people and what makes people behave as they do.

Finally, the work in which engineers engage differs from that of a skilled mechanic in that it is creative and innovative. Engineering is an art requiring the exercise of a high degree of judgment based on technical knowledge gained from extensive study and experience.

Since neither engineers themselves nor the work which they do is similar to the other kinds of people and work management has to deal with, it would seem reasonable that the methods used to deal with engineers and to control their work would be different, too.

At this point, it seems necessary, in view of some of what has been said above, to get back a bit of perspective. One of the surveys cited

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[12] William B. Given, Jr., "The Engineer Goes Into Management," Harvard Business Review (January-February, 1955).

above contained the statement that seventy-six per cent of the engineers interviewed thought management tried to manipulate people for its own purposes.[13] What is significant about that statement is that engineers should have so little idea of the functions of management that they would make the statement at all. Manipulating people is one of the more important functions of management. The ends for which people are manipulated are the ends or goals of the enterprise. And engineers are employed solely to further these ends. This point should be obvious, but apparently it is not. Therefore, it seems necessary to emphasize it at this juncture.

The basic underlying purpose of this paper is to throw some light on how to get more and better results out of available engineering manpower. To do this, people will have to be manipulated in one way or another. That engineers find this repugnant only reinforces the conclusion that engineers are different.

Motivation

Peter Drucker has said in The Practice of Management:

> It has become almost a truism in American management that the human resource is of all economic resources the one least efficiently used, and that the greatest opportunity for improved economic performance lies in the improvement of the effectiveness of people in their work. Whether the business performs depends in the final analysis on its ability to get people to perform, that is, to work. The management of worker and work is therefore one of the basic functions of management.[14]

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[13] Business Week, loc. cit.

[14] Drucker, The Practice of Management, p. 255.

There are two approaches to the problem of managing engineering manpower. The first is through the man and the second is through the work. The first has to do with motivating the man and the second deals with systems for controlling the work. It is apparent that both are needed and, as would be expected, motivating an engineer is unlike motivating an ordinary workman, and controlling engineering work is unlike controlling ordinary work. First, motivation.

In an essay published by the American Management Association, George A. Peters says repeated surveys show engineers consistently place salary in ". . . a relatively low-priority position among the things they claim to want in a job."[15] He goes on to say that some credence is lent to this claim by the fact that engineers, at the outset, choose a relatively long and difficult college curriculum. This same can, of course, be said of any curriculum to prepare for a professional career. But it is really unimportant to discuss a priority of satisfactions. It is apparent that other things besides pay are important to engineers and evidence indicates these non-financial compensations are of greater importance to professional workers, such as engineers, than non-professional workers.

We are faced, then, with finding ways besides high pay to motivate engineers. Because of the rigid wage structures imposed on federal government agencies employing engineers, these ideas are of particular interest in the Civil Service. What are these non-financial incentives which are thought to spur engineers to do more and better work?

15George A. Peters, "Non-Financial Compensation for Engineers," Optimum Use of Engineering Talent, ed. Philip Marvin (New York: American Management Association, 1961), p. 232.

Peters' essay referred to above contains a list of such incentives. They are:

1. Opportunity for promotion--outside the administrative chain.
2. Sufficient professional challenge.
3. Tolerance of individuality.
4. Identification with management.
5. Opportunity for professional growth and for professional recognition.
6. Adequate working conditions and favorable atmosphere.
7. Instilling a sense of confidence.[16]

Opportunity for Promotion

To include such an incentive as this under non-financial incentives seems odd, because promotion implies increased financial reward. However, in most organizations the way an engineer moves up is through the administrative chain. The administrator is the man who is given recognition. Both Peters and Drucker point out that promotion to administrative or managerial jobs is not necessarily a reward for an engineer.[17] Therefore, a chain of promotion should be available to compensate for increasing contributions by an individual to an enterprise without taking him away from the kind of work he can do best.

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[16] Ibid.

[17] Peters, Optimum Use of Engineering Talent, p. 232; Drucker, The Practice of Management, p. 335.

Sufficient Professional Challenge

Peters says: "Perhaps the most frequent deficiency in assigned work tasks, in the view of engineers themselves, is the lack of sufficient professional challenge. They complain their work is too often of the routine and unimaginative sort."[18] To this Drucker adds the thought that while work assignments must fit the objectives of the enterprise they must also ". . . make sense in the framework of Professional Discipline."[19]

There are, of course, a number of reasons for assigning routine work to engineers. Two of these reasons are: there is no one else to do it, or there is nothing else for the men to do. Both reasons produce gross waste of talent and money. The first situation can be remedied by hiring sub-professionals, high school graduates who did well in science, to do the work.[20] This is not easy. These people have to be trained and the employer must do the training. The second situation arises from hoarding engineers. When a manager says, "hire all you can get. We'll find something for 'em to do," he is hoarding. This is an understandable approach in a rapidly expanding business or in one with a cyclic workload. But there can be no excuse for it in a business with a level or declining workload. Needed talent is taken from the technical resources of the country and the talent is allowed to wither from lack of exercise and stimulation. In addition, it is expensive to the employer.

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[18]Peters, loc. cit.

[19]Drucker, "Management and the Professional Employee."

[20]Drucker, "Management and the Professional Employee;" Herbert S. Parnes, Effective Utilization of Engineering Manpower (Washington: The President's Committee on Scientists and Engineers, 1958).

It is interesting to note that a seven-month study of 250 companies made in 1957, by the Harvard Graduate School of Business revealed, among other things, that top management had no grasp of technical manpower requirements.[21] Ignorance like this hurts the image of management in the eyes of the engineer while at the same time discouraging his professional enthusiasm.

Tolerance of Individuality

A review of the primary factors affecting morale of engineers, as listed by the Engineers Joint Council, indicates management lacks consideration of the individual engineer as an important human being.[22] The tendency to try to "type cast" people has given rise to what has been termed the "engineer stereotype," introverted, overfactual, inarticulate. Carlton M. Barlow, Director of Personnel Development at General Dynamics Corporation, has said, ". . . engineering graduates are consistently being thought of only as engineers and not as people. . . . We are not only failing to recognize the engineering graduate as a person, but we are also failing to treat him as one."[23] There can be no question, as Charles D. Orth, III states simply, that engineers are different from non-engineers.[24]

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[21] von Peterffy, loc. cit.

[22] U. S. Subcommittee on Research and Development of the Joint Committee on Atomic Energy, Hearings, Shortage of Scientific and Engineering Manpower, 84th Cong., 2nd Sess., 1956, p. 294.

[23] Carlton M. Barlow, "The Engineer as an Individual," Optimum Use of Engineering Talent, p. 261.

[24] Orth, loc. cit.

But the fact that one engineer is different from another engineer should not be lost. Engineers are no more susceptible to categorical grouping in one "type" than are members of any other large, specially trained group. Therefore, every engineer should be handled with consideration as a distinct and important individual, be he odd or not. The engineer, as we have seen, sometimes considers the manager an odd type, too, and even "obnoxious."

Identification with Management

There is some evidence to support the claim that participation and group decision promote high productivity.[25] Certainly, it seems logical for management to relate the individuals' goals to the goals of the company. This is obviously desirable in order to develop a man who will remain in the enterprise and contribute to its ends.

One of the suggestions Drucker makes is to expose the engineer to business facts. He adds they prefer the original facts to any boiled down summary.[26] Various other writers have suggested that engineers be invited to participate in the top councils of the enterprise. The Carborundum Company is one which did this with good results.[27]

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[25]Rensis Likert and Stanley E. Seashore, "Increasing Utilization Through Better Management of Human Resources," Manpower in the United States, ed. William Haber et al (New York: Harper and Brothers, 1954), pp. 23-38.

[26]Drucker, loc. cit.

[27]Leslie E. Simon, "Engineering Organization at The Carborundum Company," Optimum Use of Engineering Talent, p. 106.

In addition to broadening the engineer's outlook and improving his appreciation of management problems, communications with the man which relate him to management will enhance his self-esteem. He will feel more important. And it is most important to every man that he himself feel important.

Opportunity for Professional Growth and Professional Recognition

> To make the very best use of technical personnel, management must encourage--and provide means for continuing professional growth. Therefore, whether he likes it or not, the engineer-manager will become involved in professional development programs. Today's rapidly expanding technology demands it; subordinates expect it; and company self-interest requires it.[28]

This factor, opportunity for professional growth and professional recognition, is one of the most important incentives. It is practically impossible to hire and keep enough trained engineers to do the work an organization needs done. This means engineers must be developed. Development is a many-edged sword. Not only does it provide the enterprise with the talent it needs, but it encourages engineers to stay on with the organization. And with development will come recognition.

The opportunity to write technical papers and appear at technical meetings and conventions must be afforded all engineers in the organization. In this way the engineer will get recognition outside his own organization.

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[28]George A. Porter, "The Need for Professional Development," Optimum Use of Engineering Talent, p. 307.

The side effects of recognition add to the multi-edged sword of professional development. Recognition heaped on the individual spills over on his organization. If the organization has a reputation for having a fine development program and is known to employ recognized leaders in the engineering field, the finest young men with the greatest potential will be attracted to it.

In any organization which expects to achieve any degree of excellence in engineering, heavy emphasis must be placed on developing the people who do the work and then on recognizing their excellence. There is no other way to build and maintain a first rate engineering organization.

Adequate Working Conditions and Favorable Atmosphere

George A. von Peterffy reported in The Management Review that during the 1957 Harvard Graduate School of Business survey cited earlier, an observation was made that eighty-one per cent of the places visited had poor physical working conditions.[29] Four out of five provided working conditions which made concentration and mental efficiency difficult.

R. K. Breese of Westinghouse Electric Corporation, writing on "The Importance of Engineering Facilities," said that the talents of the brightest engineer from the finest school may be wasted unless he is given proper facilities.[30] But what are proper facilities? The typical engineer's

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[29]von Peterffy, loc. cit.

[30]R. K. Breese, "The Importance of Engineering Facilities," Optimum Use of Engineering Talent, p. 273.

work place is a large, barn-like drafting room with endless rows of drafting tables and desks jammed against drawing files and blueprint machines. Would it be a waste of money to provide individual, well-organized, neat, modern work areas for these professional contributors? Might they work better if they had good conference rooms, a comfortable lounge area? Might they think the organization thought them important if they had really proper facilities?

And what of favorable working atmosphere? What is it? Perhaps if the other incentives were forcibly used, this one would take care of itself. If management developed a sincere concern for the engineer and showed it by actions, the resulting atmosphere would be invigorating and stimulating.

Instilling a Sense of Confidence

Perhaps the most difficult, but nonetheless necessary, part of this list of non-financial incentives is imparting to each engineer a sense that management has a fundamental faith and confidence in his ability and in his industry.[31] This requires a certain amount of tolerance on the part of managers. Relatively minor mistakes must be expected. Management reaction to error must be aimed at building confidence and experience. If a manager lets his own disappointment at failure goad him into venting his anger on an engineer who was doing the best he knew how, self-confidence will die. This is not to say that error on routine work should be tolerated. But when

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[31]Peters, loc. cit.

trial and error is involved, it is obvious there will be error. Management must continuously and generously give of its support.

Part of this feeling of confidence comes, as does a wholesome working atmosphere, from forcible application of the rest of the non-financial incentives. A man who is participating in a strong professional development program will be gaining confidence in himself. A man who is made to feel that management is interested in him, will grow in his own eyes. But making a man sure of himself, making him feel important to the enterprise, motivating him to do more and better work, will be of no avail if there is not an adequate organizational framework within which to work and if the work is not controlled. What kind of an organization and what kind of a control system will function smoothly without nullifying the effects of non-financial incentives?

Managing the Work

The answer to this question is by no means clear. Because the question deals with human beings and the environment in which human beings must work, there are a number of divergent views on how an engineering group should be organized and how the work should be controlled.

In regard to the first, a variety of approaches to engineering organization have emerged recently. We have discipline-type organizations; grouping into separate entities, mechanical, electrical, and chemical engineers. Phase organizations have also been tried in which the work is

carried through successive stages by different groups: research, development, design, etc. There are product-type organizational groupings with all the necessary disciplines for support of a single product contained in a single department. Finally, with the tremendous increase in complexity and scope of engineering projects, the systems organization has been developed.[32] All of these concepts work when applied to situations for which they are suited if there are built into the organizations certain essential characteristics.

The organizational structure must be clear-cut. Throughout this clear-cut organization there must be proper delegation of authority. In order for the first two characteristics to help the organization work properly there needs to be a strong communications system. The people in the organization must exchange information and understanding easily, constantly, and clearly. The organization must have good planning. Planning must be complete, defining objectives, mechanisms, and target points. The fifth essential characteristic is superior leadership.[33] Without these ingredients the organization will not function effectively no matter how it is structured or formed. On the other hand, if an examination of an existing organization shows it to have the five characteristics or ingredients mentioned above, no matter what the grouping concept used, the chances are excellent that it will function well.

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[32]F. E. Lovance, "The Dynamic Engineering Organization," Optimum Use of Engineering Talent, p. 53.

[33]Ibid.

Passing on to control, F. E. Lowance says:

> It goes without saying . . . that any successful operation must have the necessary checks and controls to establish whether or not the planned schedule is being attained. Proper controls are one of the signs of efficient administration, and effective planning should provide a control mechanism without any of the negative effects which hinder a dynamic group.[34]

For the next few pages various management systems will be examined. It will be apparent that the systems discussed are arranged in a definite order. The first system is the most rigid and most definite. The last system discussed is hardly a control system at all, but is, instead, a good example of dynamic leadership.

The first of these systems was described in April, 1957, by I. Nevin Palley of Temco Aircraft Corporation, now Ling-Temco-Vought.[35] He termed the Temco system the "feedback" approach to managing an engineering organization. The basic feature of this concept is a good communications loop. The communications loop assures that after the person in charge, the director in this case, gives directions to the system, the results are measured on a continuing basis and are presented to him. If the results are unsatisfactory, the directions are changed or reemphasized. The important concept is that the system is not just left alone after the original directions are given. The input is adjusted any time reports show the output does not conform to the plan. This system provides for positive direction, for correction of its own errors, and for smooth, efficient

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[34] Ibid.

[35] I. Nevin Palley, "Programming, Scheduling, and Evaluating Engineering Assignments--the Feedback Approach," Problems and Practices in Engineering Management, ed. Elizabeth Marting (New York: American Management Association, 1957), pp. 87-97.

operation--all by means of "feedback."

Because at Temco the jobs are usually rather large, they lend themselves well to extremely detailed breakdown, planning, estimating, and scheduling. Mr. Palley puts particular emphasis on the assignment of responsibility. Responsibility for each small portion of the work is fixed. Every responsible person knows what he is expected to do, how many manhours he has to do it, and when he is expected to finish. Detailed reports keep management advised of overall progress: on schedule or not; estimated vs. actual manhour expenditures; forecasted drawings released vs. actual drawings released; and forecasted distribution of manhours vs. actual distribution of manhours. These reports, on a weekly basis, provide the feedback management uses to keep the output as desired. The reports are reviewed at weekly meetings attended by the directors of the various divisions and the vice president engineering. Assessments are made and modifications of inputs are decided upon. Management is constantly aware of the status of all engineering effort in the enterprise. Management directs the operation in detail. This is a tight management system and it apparently works for this company.

The second system is also one used by an aircraft manufacturer. It was devised by Mr. A. T. Mattison, Jr., a man who gained experience in production cost control in the automobile industry. Mr. Mattison, now controller of Republic Aviation Corporation, was kind enough to provide a description of the system. His description is quoted here in full.

To begin with, we started with two fundamental premises. One was that the Engineering Administration Department would do the controlling and estimating of their costs, and the Controller's Department would act in the area of advice and surveillance. The reason for this premise was that Engineering in itself is the controlling of very skilled personnel, and the assembling of a large number of figures, facts and data alone could not measure accomplishment. The second premise was that your original estimate must be prepared in great detail and should be as accurate as is humanly possible. It was our belief that many overruns of Engineering costs were not due to lack of control, but due mainly to the fact that you underestimated the task originally. Years ago when I first entered the budgeting field, we used to laughingly say, "Our problem is quite simple. Either our estimate was too low or our costs were too high, but we sure don't know which it is."

When an estimate is prepared in the Engineering Department, it is accomplished by outlining by each one of the twenty-seven divisions their tasks to be accomplished and an expenditure chart by each department related to time for their tasks. These individual estimates are furnished to the Engineering Administration Department and consolidated into an over-all time expenditure schedule or chart. Shortly before a division starts work on a task, a work order is issued for that task with its estimated hours and its time period of expenditure. On a weekly basis, time is recorded against the individual tasks and the accumulated expenditures are compared to the time chart originally forecast. This compilation tells us that we are spending our Engineering hours in accordance with the plan, and that timed to Engineering hours we are ahead of schedule, behind schedule or on schedule. This alone is not enough. We could very well be exactly on schedule as to expenditures against time and still be in the throes of an overrun because the task accomplishment might not equal the expenditures.

This is where the cost surveillance comes into play and regardless of how closely you survey the accomplishments of the task, you could be completely misled without the full cooperation of the supervisor of each division. Our supervisors have been convinced that it is to everyone's advantage to watch each task expenditure against accomplishment, and if it becomes apparent that it is going to take more hours to perform this task than was originally anticipated, Engineering Administration be notified at the earliest possible moment. Where a certain task is known to be exceeding original expenditures, it can well be that other areas have underruns and hours can be transferred between areas. Actually we are not so concerned about our performance on each individual task and division as we are in the fact that we do not wish the job to overrun in the whole.

Located in the Engineering Department is an Assistant Controller from the Controller's Office who is constantly on the lookout for any possible overrun in any area. The selection of this person can not be overemphasized because he must be a well-qualified engineer who has sufficient knowledge of budgets to thoroughly understand his own task. He must also be given considerable power of control. An example of this is in the scheduling of manpower to the divisions to perform the tasks in the time period. Additional personnel can not be assigned to a group or division without his approval, and should a request come to him for additional personnel in a given area which is greater than the planned load to accomplish the known task, he then has a good "clue" that this department is either working ahead of schedule or is facing an overrun. This is one of our best points of control.

Manpower forecast charts by contract are exceedingly important and used extensively. The expenditure reports by jobs are prepared weekly for hours and converted to dollars with overhead expenditures added only monthly.

Every contract is under the direct management supervision of a program manager who is responsible for all phases of the contract, and it is through the program manager mainly that the information regarding the accomplishment of the scheduled work is obtained. On the smaller contracts, a single person may be program manager for several contracts.

We can not overemphasize the importance of indoctrinating the division managers of the Engineering Department with the importance of watching constantly their accomplishment against their expenditures. Figures alone just can not measure accomplishments, and there should be confidence in these managers to honestly tell when a job is not performing to schedule. It is only natural that when any individual knows that if his group overruns their estimate and it will come to light some time, it has a good stern effect at making them cost-conscious.

We believe that our premise that Engineering supervision must be set up to control themselves is of vital importance. Accountants can not do it and Assistant Controllers, no matter how many were placed in the department, would not do it unless the supervision themselves are made conscious of the fact that they must perform their tasks within the allotted hours or so notify management as soon as possible.

To send you forms, reporting mechanisms and charts would be of little value because it truly is not the mechanics that control the cost, but the desire of the supervisors to do the job at the price we originally estimated. It is fundamental that each

> operating group must know currently and quickly their expenditures to date, but they alone can measure their accomplishments.[36]

It is particularly interesting to note the emphasis Mr. Mattison puts on placing responsibility with the engineering supervisor. In this cost measurement system, one that works for a successful airframe manufacturer, the division, the work of which is being measured, is responsible for preparing the estimates originally and the division supervisor is responsible for assessing progress as the work goes along. This system keeps management apprised of work progress, but because the men whose progress is being checked participated in the preparation of the estimates and because they are responsible for making the progress reports, the adverse psychological effects of a "control" system are largely avoided. This is an information system, but one which allows management to exercise the direction necessary to keep costs in line and to meet time schedules.

The use of two examples of work control from the aircraft industry might seem out of place here were it not for the fact that the kind of work done by these firms is not unlike that done in a civil engineering organization. In an article in the August, 1961, Consulting Engineer, John Girand describes a system of managing engineering productivity used in the consulting engineering office with which he is associated.[37]

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[36]Letter from A. T. Mattison, Jr., Controller, Republic Aviation Corporation, Farmingdale, Long Island, New York, March 9, 1962.

[37]Girand, loc. cit.

The responsibility for preparation of an estimate of the direct costs which will be involved in the engineering and design work for a project is made by a project manager. In making this estimate, Mr. Girand suggests that an uninitiated project manager keep in mind Finagle's First Law of Revision:

> Information necessitating a change in design will be conveyed to the designer after, and only after, the plans are complete.[38]

When Girand's project manager has his estimates in final form the job is broken down into monthly increments of cost, payroll and direct material only. These increments are put on a report form on which is space to record actual costs each month and the project manager's estimate of the percent completion of the design. Mr. Girand comments that a new project manager is usually shocked to find how fast the supply of money dwindles and how hard it is to get that last five per cent of completion.

The moral of Mr. Girand's article is this:

> Not many consultants can afford the luxury of project managers who consistantly underestimate the cost of the engineering required on the job; who never can get the job completed; or who insist on engineering the job to death.[39]

The three methods of management of work described so far have all involved, in varying degrees, planning, estimating, scheduling, and progress reporting in a more or less formal and systematic way. In each of these cases the management of the firm took a direct interest in the administration

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[38] Ibid.

[39] Ibid.

of the engineering organization. As was mentioned earlier, a research team found this not always the case in the industrial world. Frequently, planning, coordination, and control were left completely to the chief engineer. In these instances administrative procedures were frequently confused. "Getting out the work" took too much of the time of these men. In addition, "technically trained executives and managers . . . are usually unwilling to believe or to admit that substantial improvements in the level of engineering productivity can be made."[40] These people are often products of the system they are managing and they have seldom had administrative training.

In an article entitled, "Getting More Mileage from Your Engineering Staff," George A. von Peterffy suggests the following basic leadership techniques to provide work control.

1. Plan all work carefully.
2. Select personnel for assignment to projects on the basis of availability, interest, and, if it involves group work, compatibility.
3. Discuss and carefully explain the work and the desired objective to the engineers.
4. Allow time for the engineers to study the assignment and requirements.
5. Jointly agree on and fix a completion date after recapitulating objectives.
6. Define clearly the responsibility and the scope of authority delegated.
7. Check on progress at regular intervals, and give necessary assistance and support.
8. Evaluate the work upon its completion.
9. Review the evaluation with the individuals concerned.
10. Praise as well as criticize and explain how future improvements can be made.[41]

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[40] von Peterffy, loc. cit.

[41] Ibid.

One might observe that this is simply what one would expect of a good engineering supervisor. But how often do we get what we can expect? Might not most of the problems of managing engineering manpower vanish if supervisors assumed these responsibilities?

Another view of the functions of the engineering administrator is presented by Charles D. Orth, III, in his article "More Productivity from Engineers." Mr. Orth considers it the function of administrative engineers to help rather than direct those working for them. According to Mr. Orth, an administrative engineer should have an understanding of the needs of the group and of his own operating situation. He should provide the vehicle through which the engineers report to management. He should interpret management to the engineer and the engineer to management. The administrator must stimulate creative imagination by asking questions. He serves to coordinate ideas, plans, and services and to protect engineers from pressures.[42]

Mr. Orth's ideas would find their greatest application in organizations requiring a maximum of creativity and innovation.

We have now gone from one end of the spectrum of engineering work management to the other. The system used at Temco is a tight one which serves well to manage the engineering effort involved in turning out a large volume of drawings for aircraft production. This kind of work, while it requires extensive engineering knowledge and judgment does not require a very high degree of creativity and innovation. At the other end of the spectrum, we saw Mr. Orth's description of an engineering administrator

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[42]Orth, loc. cit.

whose primary function is to create an atmosphere in which engineers can work which will allow their full creative and innovative potential to emerge. Somewhere between these two extremes lies a system which would be applicable to controlling the work done in the engineering organization of the Bureau of Yards and Docks. In the next chapter this will be discussed together with some ideas for a program of non-financial incentives for Bureau of Yards and Docks engineers.

CHAPTER III

A PRACTICAL PROGRAM

Technical Excellence

An easy way to develop a program for motivating the engineers of the Bureau of Yards and Docks and for managing the work they do would be to sit in an armchair and dream up an ideal program and system. Unfortunately, such a system, conceived in a vacuum of knowledge, would have little chance of succeeding in a real world. Therefore, the writer spent some time talking with people in the Bureau of Yards and Docks about the existing situation, the existing environment, and what needs to be done.

The first impression perceived is that there is a real awareness on the part of many in the bureau that the survival of the organization depends on its ability to provide technical engineering services to the Navy. This point was highlighted in a talk by Rear Admiral N. J. Drustrup, Deputy Chief of the Bureau, on March 27, 1962. RAdm Drustrup, speaking to the Washington Area Junion Officers' Luncheon, said that he and the chief of the bureau were in agreement that the primary job of the Civil Engineer Corps and the Bureau of Yards and Docks is to provide to the Naval Shore Establishment superior technical engineering capability.[1]

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[1]Speech by RAdm N. J. Drustrup, CEC, USN, Deputy Chief, Bureau of Yards and Docks to Washington Area Junior Officers, March 27, 1962.

The second impression the writer gained is that while the bureau has a reputation for providing superior technical engineering capability, the ice on which the organization has been skating is getting thin. The demands of the Navy for the kinds of capability the bureau has provided in the past are increasing in scope and complexity, but in the recent past the bureau has met these demands largely by farming out the work to architect engineer (A&E) contractors. As a consequence, the "in house" capability of the bureau has diminished. In some areas of engineering there are pockets of excellence. For example, in crane design the District Public Works Officer, Ninth Naval District, has a working capability. But by and large, to this observer and to others in a position to know with whom he has spoken in recent weeks, the vaunted "in house" capability looks to be more shadow than substance.

Combine these two impressions, first, that technical excellence is the key to survival for the Bureau of Yards and Docks and, second, that the technical capability of the bureau has been allowed to deteriorate, or at least has not been made to keep pace with recent developments, and it becomes obvious that the technical capability of the bureau must be rejuvenated if the organization is to survive.

There are those who will not agree with this concept. There is a school of thought which says it is unnecessary for the bureau to have "in house" engineering capability. However, the writer is not one of them. I fail to see a need for a Bureau of Yards and Docks if it does not have a unique and vigorous capability for doing engineering work. Without a

particular, Navy oriented, specialized, technical civil engineering capability "in house" the bureau might better turn its functions over to the General Services Administration. Therefore, it seems to this observer that a vigorous and sustained program is needed to redevelop an "in house" engineering capability in the Bureau of Yards and Docks.

As has been stated before, the policy of the bureau is, "a sufficient number of design projects of broad scope and complexity will be retained 'in house' to provide for continued staff development, capability, and high level performance within the organization of the Bureau of Yards and Docks or its field activities."[2]

In the recent past this policy has been given less than enthusiastic support. For the fiscal year 1962 military construction program plans and specifications for twenty-three out of one hundred fifty-six line items were prepared "in house."[3] That is nearly fifteen per cent. However, this percentage is based on numbers of jobs. Figures based on construction contract price are nearer seven per cent. This means, of course, that the smaller jobs are the ones which were done "in house." The fiscal year 1963 proposed military construction program contains two hundred eighteen line items for which preliminary engineering reports have been prepared. Twenty-five per cent of these were done "in house," but this is not necessarily an improvement as it is not an indication that final design will be done "in house."

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[2]Precepts, loc. cit., p. 16.

[3]Interview with R. A. Bowers, LT, CEC, USN, Bureau of Yards and Docks Code EC-120A, March 31, 1962.

Why is this so? Why, with a policy such as stated above, has not more "in house" engineering work been done? The answer is contained in another question. What have the engineers been doing in recent years which they can now stop doing so they can devote their time to more challenging work? They have been doing the kind of work which is difficult to find others to do; the annually funded repair projects, the checking of drawings, the multitude of special jobs.[4] They must continue to do this. What does this kind of work do to the capability of a design force? It surely does not stimulate and challenge it. It dulls it. Perhaps then, as I have alleged above, the bureau really does not, in fact, have much "in house" capability. If this is so, then having a policy such as stated above is not enough. An order which is impossible of execution is better not given, at least until circumstances are altered to make execution possible. The circumstance needing altering is the state of the technical engineering capability of the bureau. How can it be changed?

There is at the present time in Washington, among highly placed officials, a propensity to inject into their comments on the world situation a phrase to the effect that we must bear in mind that there are no simple solutions to the vexing problems facing us. This is such a problem. No one action will solve it.

A long-range, integrated program is needed. At least five things should be done. They are:

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[4]Interview with Mr. W. R. Stincheum, Engineering and Architectural Design Branch Manager, Bureau of Yards and Docks, March 28, 1962.

1. Rebuild the technical knowledge of the engineering personnel.

2. Change the structure of the organization to provide non-supervisory promotion channels.

3. Provide professional challenge.

4. Develop a system to assure a continuing workload for individual offices.

5. Improve physical working conditions.

The first of these steps, rebuilding the technical knowledge of the engineering personnel, is a two part step. First, the input of engineers at the bottom of the organization must be assured, and second, a carefully formulated program for development of engineers must be instituted. The bureau has in existence a going program of professional training and development for young college graduates.[5] This is a bright spot in the picture. A number of good people have come out of this program. However, the input is being tapered off. Three years are required for the bureau to realize benefit from a trainee taken into the program this year. Therefore, if there is a need for a continuing input of high caliber talent at the bottom of the organization, now is the time to re-emphasize the engineer trainee program.

The second part of the first step is to institute a development program for engineers now employed and those who will come in later. In August of 1960, the then deputy chief of the bureau directed that a plan be

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[5]Interview with Mr. M. B. Lewis, Bureau of Yards and Docks Code I-311.1, March 31, 1962.

prepared to provide for the development and selection of key civilian personnel in the bureau.[6] After nearly a year of study an ad hoc committee presented a comprehensive report[7] which outlines a workable plan of development and selection. If implemented, this plan would provide a firm foundation on which the bureau could rebuild its engineering work force.

The plan envisions a continuation of the policy of treating the bureau and all its field activities as one manpower pool for career planning, development, and selection. Under the plan the manpower pool would be broken down into functional groupings for career management purposes. The key to the plan is an annual inventory of key personnel and their accomplishments. Of critical importance in this plan is that although the bureau and its field organization is considered to be a single manpower pool, each engineer who chooses to participate in the plan is thought of as an individual and a separate development plan is prepared for him by his supervisor.

Provision would be made to give tuition support to key personnel wanting to further their education on their own time. In addition, each year two "scholarships" for full-time schooling, equivalent to a master's degree, would be awarded in each of four functional areas--design, construction, maintenance, and "all other" including management. To quote

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[6]Memorandum from the Deputy Chief, Bureau of Yards and Docks, August 30, 1960.

[7]Letter from Ad Hoc Committee on Replacement of Key Civilian Personnel, Bureau of Yards and Docks, July 5, 1961.

from the plan, "these scholarships would be awarded to applicants from the Bureau or field who have demonstrated the highest degree of actual and potential value to the Bureau, and whose educational plans are of greatest value to the Bureau." The plan also suggests the possibility that educational courses equivalent to Ph. D. requirements might be authorized.

The plan provides that all headquarters and field key jobs would constitute a single competitive area and that all participants in the development plan would be considered for selection to key positions in their own functional area. In line with this concept of a single manpower pool and single competitive area, bureau representatives would participate in selections for key jobs in the field.

An important feature of the above plan is that the manpower pool would be broken down into functional groupings. The grouping with which this paper is most concerned is that of engineering and design. One of the weak characteristics of this particular functional area is that, while the importance of providing a line of promotion outside the administrative chain is covered frequently in engineering-management literature, there is no such line in the organization of the Bureau of Yards and Docks. Therefore, the second major point in the five point program is that the organizational structure of the engineering and design organization of the bureau must be changed to provide such a line of promotion.

The Civil Service regulations provide for grades in the bureau of GS-15 non-supervisory engineers and in the field for GS-14 non-supervisory engineers. A hierarchy of positions from GS-11 through GS-15 non-supervisory engineers can, therefore, be set up in the engineering and design

organization of the bureau. Such a hierarchy would allow an engineer who wished to concentrate his efforts on becoming a better and more valuable professional contributor to do this and at the same time receive rewards commensurate with his increasing ability to contribute.

One of the objections that might be raised to this promotion system is that it would result in having engineers rising outside the administrative chain working for engineer-managers who were paid less and who were of lower rank than they. This is not an insurmountable problem. At the present time military officers are frequently paid less than the civilians they supervise. What is required is that administrative engineers function more responsibly and more humanly. They would have to obtain the cooperation of non-supervisory engineers by persuasion, by tact, and, where necessary, by employing the authority of more senior line officials in the organization. In any event, it is something which needs to be done. If difficulties are encountered they will have to be overcome.

The third step in the five step program is the one which is now being given first consideration. This step is to provide professional challenge. The way this should be done is gradually to increase the emphasis on the policy that "in house" capability will be used more often to do the work involved in design projects of broad scope and complexity. Admittedly there are conditions existing at the present time, particularly a decreasing budget base of operations and maintenance funds with which to support engineering personnel, which can force the hand of management. It may be that more "in house" work will have to be done before the organization is

really geared to do it. If this is the case, top management in the bureau must be prepared to accept less than perfect results. This is part of the price that will have to be paid for past policy and future engineering excellence.

The fourth major point is that a way of doing business has to be developed so that engineering groups in the field organization of the bureau can be assured of a continuing year to year workload. This will require aggressive attention in at least two areas, because two problems are involved. The first problem is that throughout a single year the workload fluctuates dramatically. The second problem is that the geographical emphasis of the military construction program changes from year to year and in the past has caused the workload in engineering and design groups in the field engineering organizations of the bureau to fluctuate. Neither of these conditions provides the kind of stability needed to develop a sense of security on the part of engineer employees. Without this sense of security the engineers who can do so will look for employment where they can get it, where they are thought of as a resource that must be husbanded.

The first problem, that of smoothing out the workload throughout a single year, has never been attacked on a massive basis at departmental level to develop a doctrine of operation and management for a design organization. A massive attack is needed by a special ad hoc committee composed of bureau personnel, departmental and field, and management analysts from consulting firms. Unparalleled imagination and, perhaps, radical departure from established practice have to be the ingredients of committee

action such as this if workable solutions are to be developed. Total, aggressive management support action will be needed to implement the solutions. This problem has been a stubborn and nagging one. It will not be overcome by a timid approach.

The second problem, that of the varying geographical emphasis of the military construction program, lends itself to solution by just such a radical departure from previous bureau practice. The concept of "contracting out" is well known and has been used, perhaps too much, in recent years. But the idea of "contracting in" can provide the kind of leveling feature needed to solve this second fluctuating workload problem. If, for instance, the design workload in the Philadelphia field office were dropping off, but the workload in Norfolk were picking up, what prevents the officer in charge of construction in Norfolk "hiring" the Philadelphia office to do some of his work just as he might hire an architect-engineer. If the Philadelphia office were qualified to do the work and had the capacity available, this action would be entirely feasible. Travel costs and travel speeds are such that distance is no longer a problem. The office "letting" the work could be just as demanding of another bureau office as of an architect-engineer contractor; perhaps even more so. Undoubtedly, there are problems in this idea which have not occurred to this observer, but problems are made for overcoming. And if the bureau is to progress, problems must be solved.

The fifth and last step in this five step program is to improve the physical working conditions of our engineers. The American Management Association is quoted by John Girand as having made the statement: "The

easiest way to waste engineering personnel is to have them work in poorly equipped laboratories; to crowd them together in noisy, substandard working quarters; or to scatter them so they cannot communicate adequately with each other."[8] Surely our people are crowded together in noisy, substandard working quarters.

A typical example of this is the Engineering and Architectural Design Branch in the departmental organization of the Bureau of Yards and Docks. Several designs have been prepared to make the spaces devoted to engineering and architectural design attractive, quiet, utilitarian, and well lit. The funds required, estimated at $40,000, have been requested a number of times, but have never been approved. Meanwhile, attractive working spaces have been provided elsewhere in the bureau. In some of these spaces functions are performed which seem to the engineers to be of less importance to the bureau than theirs.

As part of the effort to rebuild an image of engineering competence in the bureau and its engineering field offices, the importance of adequate working quarters should be emphasized from the point of view not only of the psychological effect on the engineer employee, but also of the effect on customers visiting the premises.

As "side effects" to these five steps the other needs for non-financial incentives for engineers will be well on the road to satisfaction. The engineers will feel they are being given the attention they deserve. Part of

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[8]Girand, loc. cit.

the development program will be training managers better to communicate with and understand the needs of professional contributors. Providing a stable workload, a continuing development program, an enlightened promotion system, challenging work, and a deep feeling of appreciation of the importance of engineering to the bureau will instill in every professional employee a sense of confidence and purpose.

These steps will improve the quality and increase the quantity of engineering output, but what about managing the work?

Managing the Work

Discussions with a number of people in the bureau indicate there is no clear-cut understanding of what is being sought. For so many years bureau people have talked about the ideas of the maintenance control program, that now they know no others. One of the first concepts which must be understood if the output of engineers is to be utilized effectively is a different idea of control than bureau people are used to hearing. The semantics of this word have been the subject of raging controversy for years. But because we have to use the word, we must understand its meaning, at least as applied herein. For our purposes, control does not mean the turning of knobs, regulating or directing the work. The concept of control as we are speaking of it here involves streams of information. Control as used here is nearly synonomous with the word communication.

We are seeking to know if the work is proceeding according to plan. This is all that a system of control will provide, and even achieving this is difficult. Compromises have to be made, inefficiencies have to be

accepted. What is being sought is a reasonably accurate and timely picture of what is going on in the organization shown against a background of what was planned. With this montage in hand the manager can then direct. It is most important for all concerned to understand that the control system is not an evaluation tool and that it provides no direction. Direction and performance evaluation are functions of managers, not of systems.

How can a control system provide a montage of what is going on in an organization shown against a background of what was planned? First, the plan has to be made. This plan provides one mental picture for the manager. Separate and distinct from the plan is a reporting system which provides the manager with a second picture, a picture of the working situation as it actually exists at a moment in time. These pictures are the two streams of information which constitute the control system. The manager integrates these two streams of information, forming the montage, and evaluating the real situation against the plan. The manager then decides whether or not the real situation is a close enough approximation to the plan. If it is, he takes no further management action. If it is not, he must revise the plan, or have it revised, and communicate this revision to subordinates in the form of supplemental or changed directions. It cannot be emphasized strongly enough that the manager, not the system, is the force that governs performance of the work.

A controversial question is who should prepare the first picture, the plan? In engineering and design this should be a joint effort. Top supervisors only should authorize the input of individual work requirements.

These work requirements must be estimated and then scheduled. The estimates can best be prepared by the man who does the work. Vigorous objections to this practice are usually made by those who understand neither the relationship which should exist between a supervisor and an engineer nor the purpose of a control system. The supervisor is supposed to be an experienced engineer who has some idea of how much time it should take to do the kind of work which falls under his supervision. Together, he and the engineer can arrive at agreement on a reasonable estimate of the number of manhours needed to do a job. Management must understand that this estimate will be wrong. It may be way off. But this is not supposed to be a standard; it is supposed to be a part of a plan. Even so, experience has shown that though it is extremely difficult to estimate the number of manhours of a particular discipline required in a job, the overall manhours required can usually be estimated with some degree of accuracy. The estimated work requirements, including a work requirement for consultation and one for little jobs[10] are incorporated into a loose schedule. Each work requirement estimate is then broken down to show the number of manhours that would have to be spent during successive intervals of time to insure that all the manhours would be spent by the time the work requirement is scheduled to be completed. This forms the first picture.

The second picture is formed by a stream of information from the individual supervisors. On a periodic basis, the period being the same as the interval of time into which the work requirement estimates were broken,

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[10]A minor innovation is that a number of little jobs would be combined into one work requirement. The single major work requirement would then be managed rather than a number of small work requirements.

the supervisors report the actual number of manhours applied to the work requirement during the period and their own estimate of the percentage of completion of the work requirement. When this information, which forms the picture of the working situation as it actually exists at a moment in time, is shown to the manager, he can compare it to the first picture. It cannot be anticipated that the two pictures will ever look alike. The important thing is that the manager is informed that the two pictures do not look alike. He then is in a position to manage, to rearrange the work force and the schedule if the two pictures are too different. He is spared surprises. He does not have the devastating experience of hitting a deadline and suddenly finding the job but fifty per cent complete.

It is apparent that this system is derived in part from the Republic Aviation Corporation system described earlier in this paper. Two paragraphs from that part of the paper deserve repetition here:

> We cannot overemphasise the importance of indoctrinating the division managers of the Engineering Department with the importance of watching constantly their accomplishment against their expenditures. Figures alone just cannot measure accomplishments, and there should be confidence in these managers to honestly tell when a job is not performing to schedule. It is only natural that when any individual knows that if his group overruns their estimate and it will come to light sometime, it has a good stern effect on making them cost-conscious.
>
> We believe that our premise that Engineering supervision must be set up to control themselves is of vital importance. Accountants cannot do it and Assistant Controllers, no matter how many were placed in the department, would not do it unless the supervision themselves are made conscious of the fact that they must perform their tasks within the allotted hours or so notify management as soon as possible.[11]

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[11] Mattison, loc. cit.

It is the belief of this observer that time remains for the Bureau of Yards and Docks to regain its position as a leader in the engineering field. However, vigorous steps such as outlined herein are needed now. And if a decision is made to go forward with a program such as this, a "control" system had best be set up to give management the two pictures, the plan for improvement and the existing situation. Otherwise, the force needed to overcome inertia will not be applied.

CHAPTER IV

SUMMARY

The nation, facing a demand for engineers which is rapidly outstripping the supply, needs to train more engineers, but also needs to better utilize those already trained. Two ways are available to improve utilization. The first is better management of the man; the second is better management of the work.

Better management of the man boils down to training and motivating each engineer to do more and finer work than he thinks he can do. How?

1. Devise a non-supervisory promotion chain.
2. Challenge the professional with difficult work.
3. Tolerate individuality.
4. Raise engineers' stature and include them in "management."
5. Improve working spaces.
6. Foster professional growth and recognition.
7. Instill self-confidence.

To do these things in the Bureau of Yards and Docks requires a number of steps. The first one is the hardest and the most important. Managers must start <u>now</u> believing in the possible. The bureau can again be an outstanding engineering organization. Then managers must accept that hard,

sustained, intelligent work and personal interest are needed to make this possibility a reality. Devising a new promotion scheme, creating a working development program, finding challenging work, making a new atmosphere will need a great and sustained driving force. Overcoming inertia will be exhausting of itself. But continuous energy input is needed to keep an organization such as this accelerating.

As far as managing the work is concerned, it is a matter of adapting a system which works elsewhere to the conditions under which the bureau and its field organization operate. The one suggested herein is reasonably workable, provided someone is willing to make it work. It will not manage the work. That is the manager's job. If the manager concentrates on managing rather than on "getting out the work," a montage such as described herein of two pictures, planned and actual conditions, is all that is needed. This scheme will provide the information the manager needs to manage. But like any control device, it must be used by the manager to produce results.

> The manager is the dynamic, life giving element in every business. Without his leadership the "resources of production" remain resources[1] and never become production.[2]

Finally, one point needs more emphasis. If rebuilding the engineering stature of the Bureau of Yards and Docks is to be undertaken, a program must be devised to embrace the total issue. When dealing with complex human situations such as this, simple solutions can have a fatal allure. Simple

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[1]Drucker considers manpower the "human resource."

[2]Drucker, The Practice of Management, op. cit., p. 3.

solutions belong with simple problems. Since this is a management problem of the highest order, a high order of management skill and power is needed to solve it.

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